



NI 020 814
9 Sep

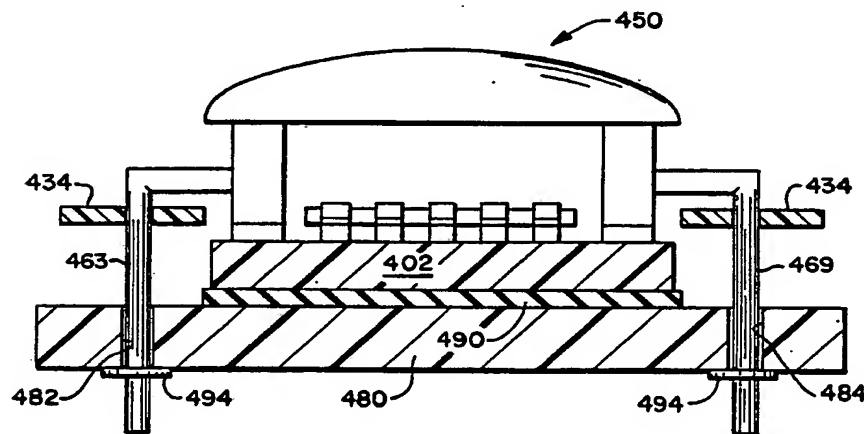
PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification⁵ : H01J 3/14</p>	<p>A1</p>	<p>(11) International Publication Number: WO 93/22787 (43) International Publication Date: 11 November 1993 (11.11.93)</p>
<p>(21) International Application Number: PCT/US92/03495 (22) International Filing Date: 28 April 1992 (28.04.92) (71) Applicants (for all designated States except US): LSI LOGIC CORPORATION [US/US]; 1551 McCarthy Blvd., Milpitas, CA 95035 (US). APPLE COMPUTER, INC. [US/US]; 20525 Mariani Ave., Cupertino, CA 95014 (US). (72) Inventors; and (75) Inventors/Applicants (for US only) : LYNCH, Brian [US/US]; 455 Greathouse Drive, Milpitas, CA 95035 (US). GAINNEY, Trevor, C. [GB/GB]; 3 Priestley Place, Larkfield, Aylesford, Kent ME20 6TX (GB). O'REGAN, Eoin [IE/IE]; COBURN, Paul [IE/IE]; NASH, Robert [-/-]; O'DONNELL, Pat [IE/IE]; Apple Computer, Inc., 20525 Mariani Ave., Cupertino, CA 95014 (US).</p>		<p>(81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LU, MC, NL, SE). Published With international search report. With amended claims.</p>

(54) Title: ARRANGEMENT FOR MOUNTING A LENS TO A SOLID STATE IMAGE SENSOR



(57) Abstract

A resilient, fixed-spacing, fixed-orientation mounting of a lens (450) with respect to a semiconductor die (430) having an array of photosensitive elements is established by forming "legs" on the lens and corresponding "landing pads" on the die, and further by providing locating pins (463, 469) passing through a flexible substrate (434) mounting the die and into a PCB (480) supporting the substrate-mounted die. In one embodiment, the locating pins are discrete elements. In another embodiment, the pins are formed integrally with the legs of the lens. In either case, the landing pads are preferably formed on the die as "bumps" formed in a tape-automated bonding (TAB) process.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	MR	Mauritania
AU	Australia	GA	Gabon	MW	Malawi
BB	Barbados	GB	United Kingdom	NL	Netherlands
BE	Belgium	GN	Guinea	NO	Norway
BF	Burkina Faso	GR	Greece	NZ	New Zealand
BG	Bulgaria	HU	Hungary	PL	Poland
BJ	Benin	IE	Ireland	PT	Portugal
BR	Brazil	IT	Italy	RO	Romania
CA	Canada	JP	Japan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SK	Slovak Republic
CI	Côte d'Ivoire	LI	Liechtenstein	SN	Senegal
CM	Cameroon	LK	Sri Lanka	SU	Soviet Union
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	MC	Monaco	TG	Togo
DE	Germany	MG	Madagascar	UA	Ukraine
DK	Denmark	ML	Mali	US	United States of America
ES	Spain	MN	Mongolia	VN	Viet Nam
FI	Finland				

ARRANGEMENT FOR MOUNTING A LENS TO A SOLID STATE IMAGE SENSORTechnical Field of the Invention

The invention relates to mounting a lens in proximity to a solid state image-sensing semiconductor device (die), or integrated circuit (IC), on a flexible substrate, such as a tape-automated bonding (TAB) tape.

Background Of The Invention

Modern charge-coupled devices and other photosensitive semiconductor devices (hereinafter "solid state image sensors") are capable of providing signals representing images formed (focused) on a surface thereof. Generally, the surface of a solid state image sensor is provided with an array (for example, rows and columns) of discrete photosensitive semiconductor elements (for example gates or junctions), and particular array locations correspond to a particular "pixel" in the image. Modern video cameras, for example, use discrete lens systems (optics) to focus images onto such solid state image sensors.

While excellent signal representations of images can be obtained with such systems, they tend to be both cumbersome and expensive. Generally, solid state image sensors used to provide

image-quality resolution, pixel-based signals representing image information are referred to as "camera chips".

Generally speaking, there are three distinct techniques of packaging a semiconductor device (die), in any case said package having leads or the like exiting the package for electrically connecting the packaged die to other components, either by mounting directly to a printed circuit board or by plugging the packaged device into a socket which, in turn is mounted to a printed circuit board. These techniques generally include:

(a) plastic packaging, wherein plastic molding (moulding) compound is disposed about a semiconductor die connected to some form of lead frame;

(b) ceramic packaging, wherein a die is mounted within and connected to lead traces (fingers) formed as layers in a multilayer ceramic package; and

(c) flexible substrate packaging, wherein a die is mounted to a flexible substrate having a conductive layer patterned to form lead traces (fingers), which traces are supported by a plastic (for example, polyimide) layer. The die is bonded, such as with bond wires or using a tape-automated bonding (TAB) process to inner ends of the lead fingers.

In the main hereinafter, TAB bonding a die to a flexible substrate is discussed.

In tape-automated bonding (TAB), "bumps" typically formed of gold, are located on either the die ("bumped die") or on the inner ends of the lead fingers ("bumped tape"). See, for example, U. S. Patent No. 4,842,662, Figures 5 and 6, respectively, incorporated by reference herein. In the main hereinafter, "bumped die" TAB bonding is discussed.

One attribute of a flexible substrate mounting for semiconductor dies is that the substrate is not very rigid. Such flexibility does not lend itself well to structural

stability, and it is known to provide some additional structure to the substrate, once the die is mounted and connected thereto, to rigidize the substrate. This may simply include an overlying layer of "glob-top" epoxy, which also seals the die from the environment.

Disclosure Of The Invention

It is an object of the present invention to provide an improved solid state image sensor.

It is a further object of the present invention to provide an improved arrangement for mounting a lens to a solid state image sensor.

It is a further object of the present invention to provide an improved arrangement for mounting a lens to a solid state image sensor, in the environment of relatively-flexible, tape-like substrate mounting the solid state image sensor, especially with tape-automated bonding (TAB) techniques.

It is a further object of the present invention to provide an improved technique for mounting a lens and a semiconductor device to a flexible substrate.

According to the invention, a relatively-flexible, tape-like substrate for mounting a semiconductor device (die) has a patterned, conductive layer of fine-pitch leads (traces, fingers) extending into a central area in which a semiconductor die is connected to inner ends of the leads. The substrate includes an underlying insulating (for example, plastic film, particularly polyimide) layer (tape) supporting the leads, the plastic film layer having an opening larger than an area defined by the die. For TAB processes, the opening in the plastic film

layer is also larger than an area defined by the inner ends of the conductive leads so that inner end portions of the leads remain exposed past the opening in the plastic film layer for TAB connecting the leads to the semiconductor device. In the case of wire bonding (versus TAB), it is not necessary that the leads extend past the opening.

Further according to the invention, the semiconductor device (die) is a solid state image sensor having a plurality of light-sensitive elements disposed in a "pixel" array across a planar front surface of the die, and the conductive traces are connected to bond pads (or bumps) on the front surface of the die, which bond pads are connected to the individual light-sensitive elements in the pixel array. Preferably, the conductive traces extend onto the front surface of the die from only two opposite edges thereof. Preferably, the inner ends of the conductive traces are TAB bonded to the semiconductor device. Preferably, a "bumped die" TAB process is used, wherein bumps for TAB bonding are formed on the die. Alternatively, a "bumped tape" TAB process can be used, wherein bumps for TAB bonding are formed directly on the lead fingers.

Further according to the invention, a lens element having a preferably round body portion is formed having an area corresponding to the area of the photosensitive element array and a bottom surface facing towards the array. The lens element is provided with at least two legs formed integrally with and extending from the lens body towards the die. The front surface of the die is provided with corresponding at least two "landing pads", upon which portions of the two legs rest, to establish a fixed, predetermined vertical (z-axis) spacing between the lens and the die. These landing pads are preferably formed in the same process and manner as the TAB bumps on the front surface of the die.

According to a feature of the invention, other portions of the legs are provided with holes aligning with pins extending up from a printed circuit board (PCB) through the flexible substrate and through the holes in the legs, for establishing a fixed, predetermined planar location (x-axis and y-axis) and angular orientation (theta-axis) of the lens with respect to the die, and for biasing the lens legs onto the landing pads of the die.

In an alternate embodiment of the invention, the other portions of the legs are provided with pin structures extending through holes in the flexible substrate and through holes in the printed circuit board (PCB) for similarly establishing a fixed, predetermined planar location (x-axis and y-axis) and angular orientation (theta-axis) of the lens with respect to the die, and for biasing the lens legs onto the landing pads of the die.

Other objects, features and advantages of the invention will become apparent in light of the following description thereof.

Brief Description Of The Drawings

Figure 1 is a top plan view of an arrangement for mounting a lens to a solid state image sensor, according to the present invention.

Figure 2 is a side cross-sectional view of the arrangement of Figure 1, taken on a line 2-2 through Figure 1.

Figure 3 is a side cross-sectional view of the arrangement of Figure 1, taken on a line 3-3 through Figure 1, at ninety degrees to the side cross-sectional view of Figure 2.

Figure 4 is a side cross-sectional view, similar to Figure 2, showing an alternate embodiment of the arrangement for mounting a lens to a solid state image sensor, according to the present invention.

Figure 5 is a side cross-sectional view, similar to Figure 4, showing additional features of the alternate embodiment of the invention.

Detailed Description Of The InventionFIRST EMBODIMENT

Figures 1, 2 and 3 show an embodiment 100 of the present invention. As best viewed in Figure 1, a semiconductor die 102 is mounted and connected to a substrate 104.

The die 102 is a solid state image sensor, having a plurality of photosensitive elements 106 arranged in an array (dashed lines) in a central area 108 on the front surface 110 of the die 102. The array 108 may include up to about 20,000 photosensitive elements 106, each photosensitive element having an array location (for example, column, row) corresponding to a "pixel" of image information. These photosensitive elements 106 are formed in any suitable manner, such as charge-coupled devices, photosensitive silicon gates, etc.

The die 102 has four side edges 112, 114, 116 and 118. The edge 112 is opposite the edge 116, and the edge 114 is opposite the edge 118. A plurality of bond pads (sites) 120 are disposed on the front surface 110 of the die 102, just slightly within two opposite edges 114 and 118. There are shown eight such bond pads 120 on each of these two opposite edges 114 and 118.

Suitable circuitry (not shown) is disposed on the front surface of the die, outside the pixel array area 108, for providing image pixel signals out of the array of thousands (for example, 20,000) of individual photosensitive elements 106 by means of the relatively limited number (for example, sixteen) of bond pads 120. This is according to well known techniques.

SUBSTITUTE SHEET

The substrate 104 is a flexible substrate, comprising:

- (a) a metal foil layer 130 patterned into individual conductive lines (traces, fingers) 132; and
- (b) an underlying layer 134 of plastic, such as polyimide, film or tape.

Inner ends 136 of the lead traces 132 extend within an opening formed by an inner peripheral edge 138 of the plastic film layer 134, and the inner ends 136 of the lead fingers 132 extend slightly over the front surface of the die 102, over the bond pads 120, and are aligned with the bond pads 120.

As best viewed in Figure 3, in a "bumped die" TAB bonding technique, conductive bumps 140 are deposited onto the die bond pads (sites) 120. These bumps 140 are typically formed of gold, and are plated or otherwise deposited onto the die bond sites 120. The die 102 is brought into juxtaposition with the substrate 104, and the inner ends 136 of the conductive traces 132 are TAB bonded to the bumps 140 on the die bond sites 120. This is according to known TAB techniques. Alternatively, the bumps (140) could be formed on the inner ends 136 of the conductive traces 132, again according to known TAB techniques ("bumped tape").

As best viewed in Figure 3 (omitted from Figure 1), a layer of glob-top epoxy 142, or the like, is applied over the inner ends of the leads 132, including an area extending outward partially over the plastic film layer 134, and including an area extending inward partially over the die 102. This helps hermetically seal the connections between the lead traces 132 and the die 102, and also helps to support the die 102 with respect to the substrate 104. The "substrate" 104 includes the lead layer 130 and the plastic film layer 134.

According to the invention, a lens 150 is provided in close

proximity to the die 102, for focusing an external image (see Figure 2, light rays "↓↓↓") onto the pixel area 108 on the front surface 110 of the die 102, particularly onto the array of photosensitive elements 106 on the front surface of the die.

Inasmuch as the die 102 is solid state image sensor, specifically intended to function as a "camera chip" (although not specifically in a video camera, per se), it is essential that the external image be in focus on the front surface of the die. Hence, it is critical that the lens 150 be accurately located at a distance "f" (see Figure 2), representing the focal length of the lens, from the front surface of the die. In this example, the focal length of the lens is 2 millimeters (mm).

As best viewed in Figure 2, the lens 150 has a round "body" 152 forming an optical element, and the bottom surface 154 of the lens body 152 is oriented towards the front surface 110 of the die 102. Two legs 154 and 156 are formed integrally with the lens body 152, and extend outward and downward (that is, towards the die, as best viewed in Figures 2 and 3) from diametrically-opposed locations on the lens body. This is termed a "C-mount", the legs 154 and 156 forming the two "legs" of the "C". The legs 154 and 156 are parallel to each other, and spaced apart sufficiently to clear (not impede with) the array area 108.

More particularly, the leg 154 has a portion 158 extending radially from the lens body 152, thence a portion 160 extending at a right angle (to the portion 158) co-axially with respect to the lens body towards the die, thence a portion 162 extending at a right angle (to the portion 160) outward from the center of the die parallel to a plane defined by the front surface 110 of the die.

Similarly, the leg 156 has a portion 164 extending radially

from the lens body 152, thence a portion 166 extending at a right angle (namely, ninety degrees) co-axially with respect to the lens body towards the die, thence a portion 168 extending at a right angle (to the portion 166) outward from the center of the die parallel to the plane of the die.

The leg portions 158 and 164 are collinear and extend in diametrically opposed directions outward from the lens body 152. The leg portions 160 and 166 are parallel to each other, and spaced apart from each other by a distance at least as great as the diameter of the lens body 152. The leg portions 162 and 168 are collinear and extend in opposite directions with respect to the center of the die, and also with respect to the lens body.

The leg portions 162 and 168 are parallel to the plane of the die, and extend from within the outer edges 116 and 112, respectively, of the die to beyond the outer edges of the die.

The lens 150 is positioned so that the legs 154 and 156 are disposed just within opposite side edges 116 and 112, respectively, of the die, and such that the leg portions 162 and 168, respectively, rest on the front surface of the die.

The lens body 152 and legs 154 and 156 are formed integrally with one another, of clear plastic, such as acrylic. Hence, they are relatively hard and stiff. And, as we know, silicon dies (for example, 102) are especially brittle. Thus, if the lens were mounted directly to the die, it is likely that the die would crack. Hence, a "shock-absorber" is included for mounting the lens to the die.

"Landing pads" 170 and 172 are formed, outside the central area 108, at opposed locations on the front surface of the die

for resiliently mounting the legs 154 and 156, respectively. The attributes of these "landing pads" 170 and 172, which function as "shock absorbers" for mounting the lens to the die, are that they are resilient (ductile) and are capable of being applied with a precise (known, fixed) thickness to the front surface of the die.

According to the invention, the landing pads (or "spacers") 170 and 172 are formed in the same manner and of the same material as the bond bumps 140 (Figure 3) formed in the TAB process. TAB processes are well defined, and spacers (170, 172) having a thickness of 25 microns, plus/minus 3 microns, are readily achieved. The ability to deposit (or plate) the spacers 170 and 172 onto the front surface of the die with such precision, allows for accurately positioning the lens with respect to the die, which is critical when dealing with a limited field of focus (depth of image field) for the lens. In this example, the depth of field for the lens is 30 microns, which is an order of magnitude larger than variations (3 microns) expected in the thickness of the spacers 170 and 172.

With the lens resting on the die, via the intermediary of the spacers 170 and 172, it is possible to focus an external image onto the photosensitive element array of the die with image-quality resolution.

As best viewed in Figures 1 and 3, the landing pads 170 and 172 are wider than the respective leg portions 162 and 168. This is to ensure that the leg portion rests entirely on the respective landing pad. In this sense, the landing pads have a larger "footprint" than the respective leg portions.

It has been described how the lens rests upon the die, and how the legs 154 and 156 and landing pads 170 and 172, respectively, can establish a relatively precise vertical (z-axis) positioning of the lens with respect to the die. The

position of the lens in the plane of the die (x-axis and y-axis) is also important, as is the rotational position (theta) of the lens with respect to the die. It is also important to securely mount the lens with respect to the die. There follows a description of establishing planar (x-axis, y-axis and theta) positioning of the lens, as well as means for holding the lens in place with respect to the die.

As best viewed in Figure 2, the die 102 and substrate 104 (only the plastic tape layer 134 of the substrate 104 is visible in Figure 2) are usually ultimately mounted to a printed circuit board (PCB) 180, or the like, for connecting the packaged (substrate-mounted) die to external system components (not shown). This is readily accomplished with a layer 181 of suitable adhesive between the backside of the die and the front side of the PCB.

As best viewed in Figures 1 and 2, the leg portions 162 and 168 of the legs 154 and 156, respectively, extend substantially beyond the edges 116 and 112, respectively, of the die, and over the substrate 104. As best viewed in Figure 1, the top conductive layer 130 of the substrate is patterned to have conductive traces 132 only on two opposite sides 182 and 183 of the plastic layer 134 aligned with the two bumped edges 114 and 118 of the die, and is patterned not to have conductors (or any foil at all, for that matter) in areas 184 and 185 corresponding to the non-bumped edges 116 and 112 of the die where the leg portions 162 and 168 will rest upon the die and extend out over the substrate 104. In other words, the lens is oriented so that the leg portions 162 and 168 extend at ninety degrees to the conductive traces 132, so that they are over only the plastic layer portion 134 of the flexible substrate 104.

The leg portion 162 extending over the plastic substrate

area 184 is provided with locating holes 202 and 204 aligned over the plastic substrate area 184. Two holes are preferred, at least one is required. Similarly, the leg portion 168 extending over the plastic substrate area 185 is provided with two locating holes 206 and 208 aligned over the plastic substrate area 185.

A pin 210 is provided extending "normally" (at ninety degrees) from the front surface of the PCB 180 towards the leg portion 162, through an aligned hole 203 in the plastic film layer 134 and through the hole 202 in the leg portion 162. A similar pin 212 is provided extending from the front surface of the PCB, through the plastic film layer, towards the leg portion 162 and through the hole 204, as best viewed in Figure 3.

Similarly, two pins are provided extending from the front surface of the PCB towards the leg portion 168 and through the two holes 206 and 208. In Figure 2, one of these pins 214 is shown extending through the an aligned hole 207 in the plastic film layer 134 and through the hole 206 in the leg portion 168.

The pins (210, 212, 214) are anchored with a suitable adhesive (not shown) into the PCB, and extend through the respective locating holes (202, 204, 206, 208) in the respective leg portions (162, 168). The leg portions 162 and 168 are then anchored down onto the PCB by suitable mechanical means, such as star washers 220 atop the respective leg portions, a suitable adhesive (not shown), or deformation (or "wedging", not shown) of the portions of the pins extending through the locating holes beyond the leg portions. The locating pins may extend suitable entirely through the PCB, and be retained by a head (enlarged pin diameter) on the back side of the PCB.

Figure 2 is "nearsighted", in that it does not show the conductors 136, bond pads 120 or bond bumps 140 in the far

background.

As best viewed in Figure 2, the locating pins (210, 214) securely retain the substrate 104, die 102 and lens 150 onto the PCB 180, and there is a gap between the plastic layer 134 of the substrate 104 and the PCB 180. In some instances, this gap may be advantageously employed to resiliently bias the lens down onto the die, for example by how far the star washers (220) are positioned down the length of the locating pins. However, it may be more preferred to reduce the gap, while retaining some downward bias on the lens, while controllably limiting the downward bias, by interposing suitably-sized spacers 222 (see Figure 2), somewhat smaller than the gap between the substrate and the PCB, around the respective locating pins between the PCB and the substrate.

The locating pins (210, 212, 214, etc.), locating holes (202, 204, 206 and 108), and corresponding aligned holes (203, 207) for the locating pins through the plastic film layer 134, establish the planar position (x-axis, y-axis, theta-axis) position of the lens 150 with respect to the die 102, hold the lens securely in position against the die, and bias the lens against the front surface of the die. Further, the landing pads 170 and 172 perform a shock absorbing function so that the legs of the lens do not damage the die.

It should be understood that the legs 154 and 156 can also be formed non-integrally with the lens body 152, as separate elements, although integral forming (as discussed above) is preferred.

It should be understood that a "bumped tape" TAB process can be employed, although it would then be necessary to form the landing pads 170 and 172 in a separate process since the die is not being otherwise "bumped" for TAB bonding.

It should be understood that it is not necessary that the

flexible substrate is a TAB substrate, and that the die can be wire bonded to the substrate. However, as with a "bumped tape" TAB process, it would be necessary to separately form the landing pads (namely, separate from a "bumped die" step).

It should also be understood that the locating pins (for example 210 and 214) could extend completely through the PCB (180), could have a head of increased diameter atop the substrate, and could be anchored (for example with star washers) on the lower side of the PCB.

These variations on the disclosed mounting technique will be evident to those of ordinary skill in the art to which this invention most nearly pertains, without further illustration, based on the disclosure contained herein.

SECOND EMBODIMENT

Figures 4 and 5 show an alternate embodiment of the invention, and correspond generally to the view of Figure 2.

In this embodiment, the legs are formed differently than they were in the first embodiment (Figures 1-3). To wit, the lens 450 has a body portion 452 (similar to the body portion 152 of Figures 1-3) with a lower surface 454 (154) facing the die 402 (102).

In this embodiment, the lens is provided with two "vertical alignment legs" 454 and 456, again preferably formed integrally with the lens body. The vertical alignment legs 454 and 456 are parallel to each other and spaced apart, and extend from the bottom 454 of the lens, towards the die 402, and establish a predetermined vertical (Z-axis) spacing between the lens body 452 and the front surface 410 of the die. These legs 454 and 456 have a rectangular cross-section, and are flat at their lower ends 455 and 457, respectively. These ends 455 and 457 contact the landing pads 470 and 472, respectively, on the front surface of the die. As in the first embodiment (Figures 1-3) the landing pads 470 and 472 are preferably formed in the TAB process, and provide a resilient resting place for the lens, and are larger in area than the "footprint" of the vertical alignment legs.

The view of Figure 4 is not "nearsighted", in that TAB bumps 440 (140), conductive traces 436 (136) and the plastic film layer 434 (134) can be seen in the distance, between the vertical alignment legs 454 and 456.

Lateral alignment legs 462 and 468 extend from approximately midway along the vertical extent of the vertical

alignment legs 454 and 456, respectively, outward (parallel to the plane of the die) a suitable distance to be over the plastic film layer 434. At this point, the lateral alignment legs 462 and 468 turn (ninety degrees) downward and extend through respective holes in the plastic film layer. The downward-oriented portions 463 and 469 of the lateral alignment legs 462 and 468, respectively, are round in cross-section, similar to the alignment pins 210 and 214 of the first embodiment (Figures 1-3). In this manner, the planar alignment (s-axis, y-axis, theta-axis of the lens is established with respect to the substrate-mounted die.

The pin-like portions 463 and 469 are sufficiently long to extend completely through the plastic film layer, and through respective holes 482 and 484 in an underlying printed circuit board 480 (PCB, compare 180).

Turning now to securing the lens in place, and biasing the lens against the die, attention is directed to Figure 5.

A layer 490 of a compliant (resilient) material, such as elastomer, is interposed between the front of the PCB 480 and the back of the die 402. The layer 490 is at least as large (in area) as the die, but is preferably not much (such as less than ten percent) larger. This compliant layer 490 will establish a limited downward bias of the lens against the die .

As mentioned hereinabove, the pin-like portions 463 and 469 of the vertical alignment legs extend fully through the PCB 480. On the lower side of the PCB, the pin-like portions are secured against the bottom of the PCB in any suitable manner, such as with star washers 494, or by expanding their diameter (swaging).

It should be understood that each lateral alignment leg

(462, 468) can be "forked", which is to say can have two pin-like portions extending outward and downward from the respective vertical alignment leg (454, 456). Or, they can simply be flat. Similarly, there are readily provided two pin-like portions (463, 469) on each of the lateral alignment legs (462, 468), corresponding to the two pins per side (that is, per leg) of the first embodiment.

Additional Comments

The landing pads (170, 172, 470, 472) are preferably formed of gold, in the same process and with the same material as the TAB-bumps are formed on the front surface of the die. However, the landing pads can be formed of copper, or of solder, or of other ductile material that will alleviate any tendency for the lens legs to crack the die, and that can be applied by electroplating or depositing onto the front surface of the die.

Inasmuch as the landing pads can be applied to the front surface of the die with relatively high precision (with respect to their thickness), and the legs of the lens can be formed with reasonably good precision, it is possible to provide a known, critical spacing between the lens body and the front surface of the die. In other words, it is possible to "reference" off of the front surface of the die.

The invention advantageously employs the requirement for only a relatively small (for example, sixteen) bond sites on the front surface of the die, these bond sites conveniently disposed only along opposite edges of the die.

While two diametrically-opposed legs have been disclosed, it should be understood that any suitable number of legs (namely, at least two) could be employed.

The invention is particularly well suited to focusing external images onto any optically-sensitive electronic device. It is of particular relevance to the situation where the alignment of the lens with respect to the sensitive surface of the device requires accurate alignment of the lens in both the vertical and lateral (planar) dimensions, such as for an image sensor.

Given the situation where a lens must be positioned above

an electronic device to within a tolerance of a few tens of microns in the vertical dimension, it is advantageous that the lens have integrally-formed vertical alignment legs formed to extend from the lens to the electronic device. The legs are formed to contact the electronic device only in areas where a controlled thickness of resilient material (landing pads) can be readily applied. Since the process of applying the landing pads to the electronic device is well controlled, the vertical spacing of the lens above the electronic device will be commensurately well controlled.

The discrete pins, or integrally-formed pin portions of the legs, establish the planar (lateral) position of the lens with respect to the electronic device, and also are used to bias the lens downward against the electronic device.

The layer 490 of material shown (Figure 5) between a printed circuit board and the die is preferably an elastomeric spacer, or a gel dispensed onto either the back side of the die or onto the front side of the printed circuit board.

The portions of the discrete pins, or of the pin portions of the legs, extending through the leg portions or printed circuit board, respectively, can be fixed in place using any suitable technique, such as with star washers, with an adhesive, or by local deformation of the extending pin portions by application of heat via a hot tool or ultrasonic energy, or by soft swaging.

CLAIMS

What is claimed is:

1. Arrangement for mounting a lens to a solid state image sensor, comprising:

- a semiconductor die having a front surface;
- a plurality of photosensitive elements formed in a central area on the front surface of the die;
- landing pads formed on the front surface of the die, outside of the central area having photosensitive elements;
- a lens structure having a lens body for focusing external images onto the photosensitive elements in the central area;
- legs extending from diametrically opposed regions of the lens body and supported by the landing pads; and
- means for biasing the lens down onto the die.

2. Arrangement for mounting a lens to a solid state image sensor, according to claim 1, further comprising:

- a flexible substrate having a layer of conductive traces extending onto the front surface of the die from two opposite edges thereof, said conductive traces supported by a plastic film layer.

3. Arrangement for mounting a lens to a solid state image sensor, according to claim 2, wherein:

- the legs are supported adjacent two intermediate opposite edges of the die, so as not to interfere with the conductive traces.

4. Arrangement for mounting a lens to a solid state image sensor, according to claim 2, wherein:

inner ends of the conductive traces are connected to corresponding bond sites on the front surface of the die using a tape-automated bonding (TAB) process employing "bumps" between the bond sites and the inner ends of the conductive traces.

5. Arrangement for mounting a lens to a solid state image sensor, according to claim 4, wherein:

the TAB process is a "bumped die" process wherein the bumps are formed as TAB-bumps on the bond sites on the die; and the landing pads are formed of the same material and in the same process as forming the TAB-bumps on the die.

6. Arrangement for mounting a lens to a solid state image sensor, according to claim 1, further comprising:

a flexible substrate having a layer of conductive traces extending onto the front surface of the die from two opposite edges thereof, said conductive traces supported by a plastic film layer; a first portion of each leg extending downwardly from the lens body onto the front surface of the die, and resting on a respective the landing pad, for establishing a known vertical separation of the lens from the front surface of the die;

a second portion of each legs extending outwardly from the die over the plastic film layer;

pins extending from the second portions of the legs through an area of the plastic film layer, for establishing a known planar position of the lens with respect to the die.

7. Arrangement for mounting a lens to a solid state image sensor, according to claim 6, wherein:

the pins extend through the plastic film layer in areas clear of conductive traces.

8. Arrangement for mounting a lens to a solid state image sensor, according to claim 6, wherein:

the pins are formed integrally with the second portions of the legs;

the pins extend through a printed circuit board supporting, on one side of the printed circuit board, the substrate-mounted die; and

ends of the pins extending through the printed circuit board are fixed to an opposite side of the printed circuit board for biasing the lens downward onto the die.

9. Arrangement for mounting a lens to a solid state image sensor, according to claim 8, further comprising:

a layer of elastomeric material interposed between the one side of the printed circuit board and the die, for establishing a downward bias of the lens against the die.

10. Arrangement mounting a lens to a solid state image sensor, according to claim 6, wherein:

the pins are separate and distinct from the second portions of the legs;

the pins extend through aligned holes in the second portions of the legs;

the pins extend into a printed circuit board supporting, on one side of the printed circuit board, the substrate-mounted die; and

ends of the pins extending through the second portions of the legs are fixed to the legs in a manner to exert a bias on the lens holding the lens downward onto the die.

AMENDED CLAIMS

[received by the International Bureau on 13 May 1993 (13.05.93);
new claim 11 added; other claims unchanged (1 page)]

11. An integrated circuit camera arrangement, comprising:
- a semiconductor substrate;
 - an optically active array formed on the semiconductor substrate;
 - a focusing assembly having at least one end contiguous with the semiconductor substrate outside of the active array and locating the focussing assembly a fixed distance in a first dimension from the active array;
 - said focussing assembly being located in second and third dimensions relative to the active array.

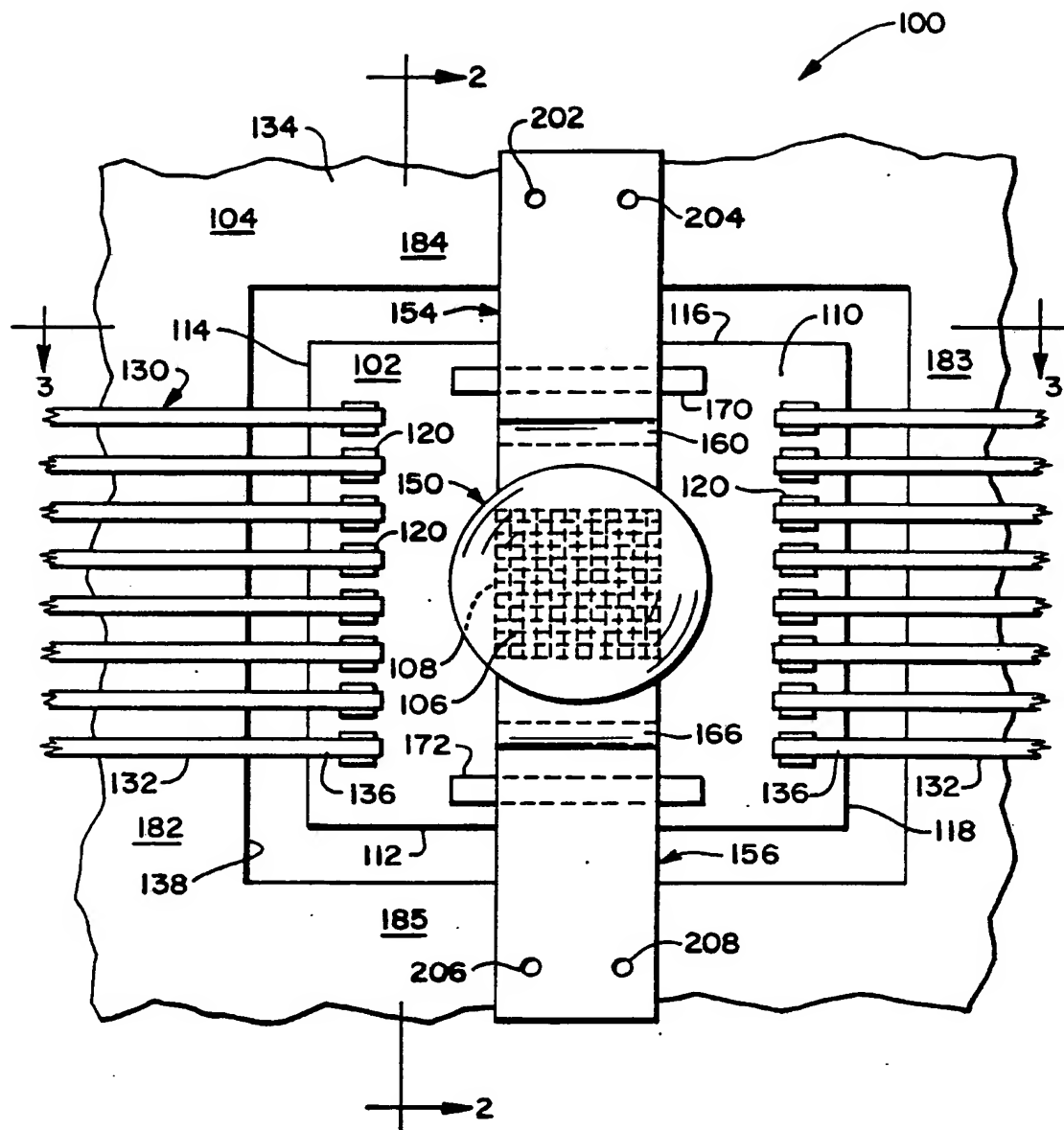


FIG. 1

SUBSTITUTE SHEET

2/3

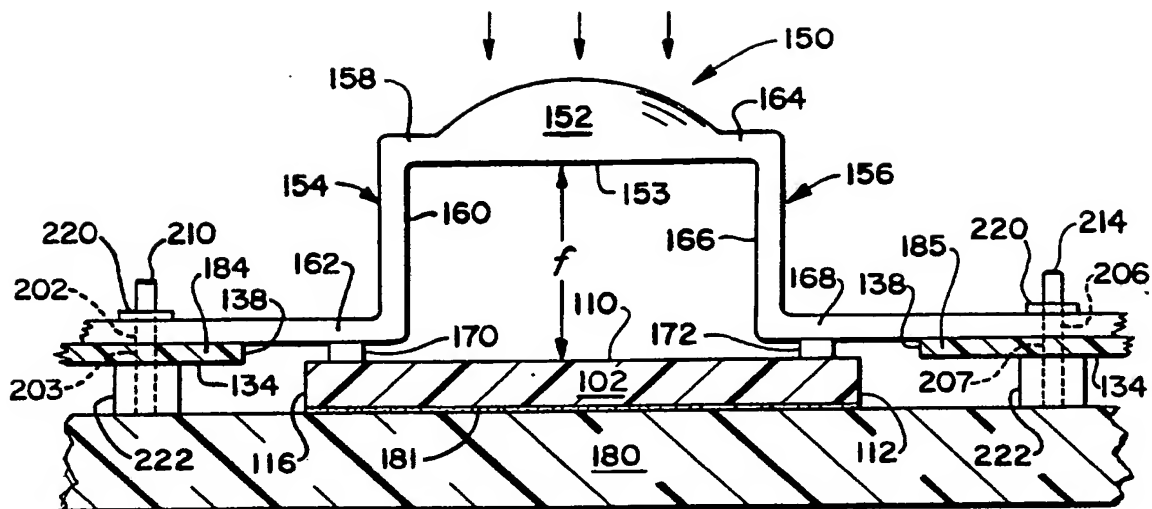


FIG. 2

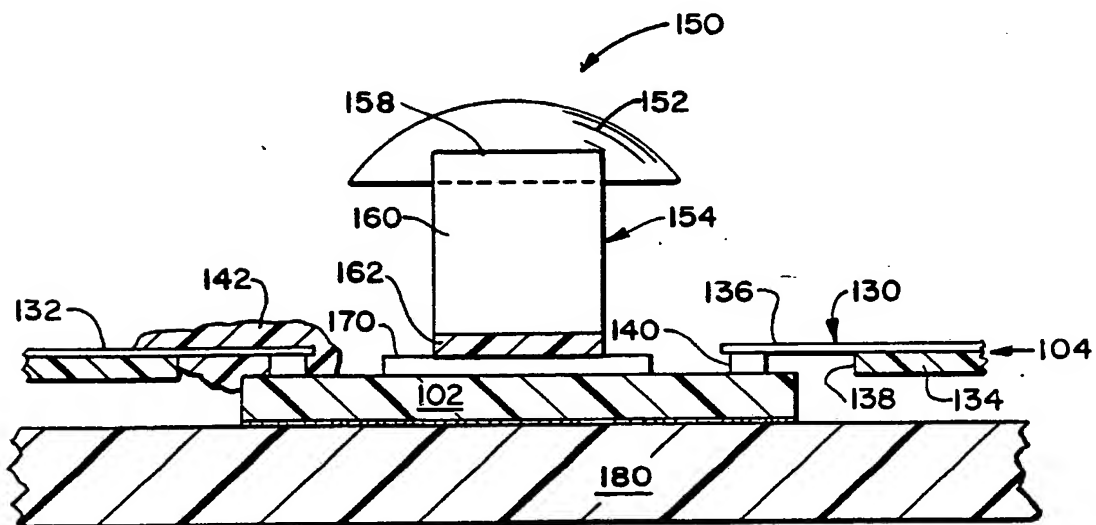


FIG. 3

SUBSTITUTE SHEET

3/3

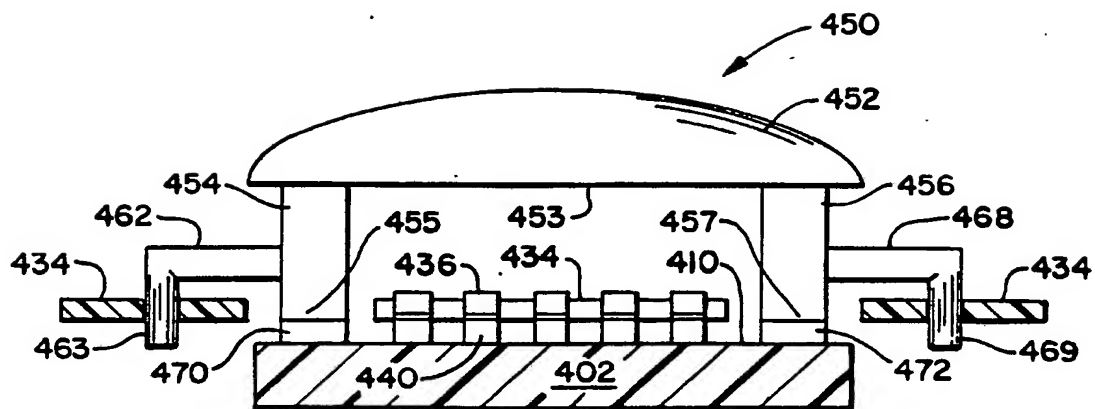


FIG. 4

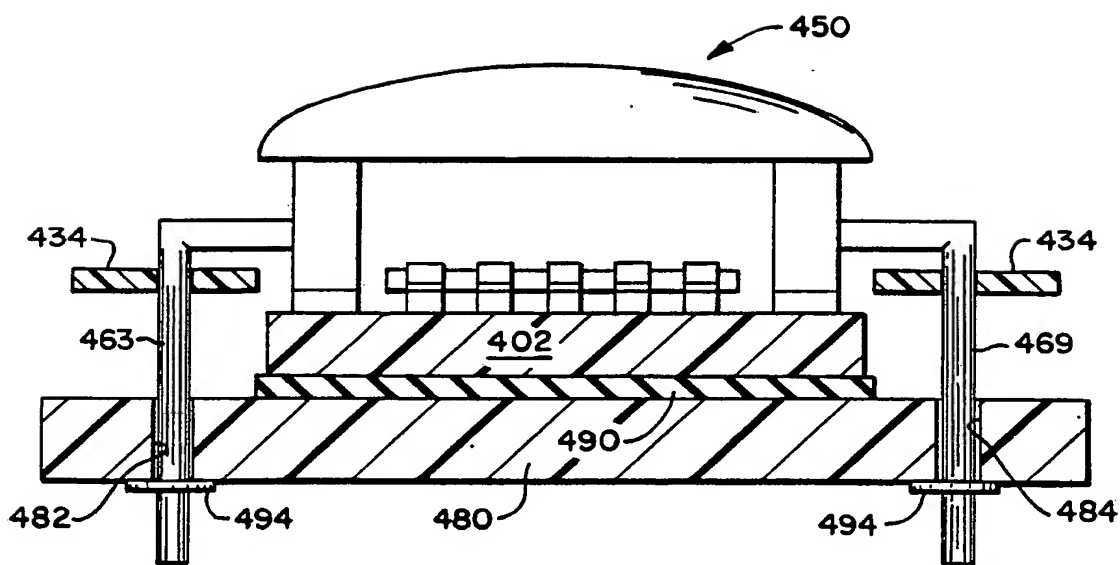


FIG. 5

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International application No
PCT/US92/03495

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H01J 3/14

US CL :250/216

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 250/216; 250/208.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,425,501 (STAUFFER) 10 January 1984 See the entire document.	1-8
A	US, A, 4,553,036 (KAWAMURA ET AL.) 12 November 1985 See the entire document.	1-8
A	US, A, 4,636,631 (CARPENTIER ET AL.) 13 January 1987 See the entire document.	1-8
A	US, A, 4,733,096 (HORIGUCHI) 22 March 1988 See the entire document.	1-8

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

Special categories of cited documents:	
A document defining the general state of the art which is not considered to be part of particular relevance	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
E earlier document published on or after the international filing date	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	*A* document member of the same patent family

Date of the actual completion of the international search 12 AUGUST 1992	Date of mailing of the international search report 20 AUG 1992
Name and mailing address of the ISA/ US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer NGUYEN NGOC-HO INTERNATIONAL DIVISION Telephone No. (703) 308-4116